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Acute Appendicitis and Peritonitis ACUTE APPENDICITIS ■ ■INCIDENCE AND EPIDEMIOLOGY Acute appendicitis is the most common acute general surgery emer gency affecting the abdomen, with a rate of ~10–11 cases per 10,000 people annually over the past several decades affecting biological males and females equivalently. Appendicitis still occurs most commonly in 10- to 19-year-olds, although the worldwide incidence and average age at diagnosis appear to be increasing gradually, whereas disability from complications and mortality appear to be decreasing. Significant differences in geographic risk variation are noted in the United States and worldwide. The risk of perforation is ~10–20% and is a significant cause of excess morbidity for all patients, but the risk appears to be signifi cantly higher in patients <5 or >65 years of age. Patients with higher socioeconomic status appear to have lower risk of appendicitis with or without perforation. It is also important to note that the incidence of appendiceal tumors also appears to be increasing. How best to manage patients who present with an appendiceal mass and small localized abscess without perforation is controversial, especially whether interval or immediate appendectomy should be per formed when both can be appropriate depending on the clinical details. PART 10 Disorders of the Gastrointestinal System ■ ■PATHOGENESIS OF APPENDICITIS AND APPENDICEAL PERFORATION Appendicitis was first described in 1886 by Reginald Fitz. Its etiology is still not completely understood. Fecaliths, incompletely digested food residue, lymphoid hyperplasia, intraluminal scarring, tumors, bacteria, viruses, and inflammatory bowel disease have all been associated with inflammation of the appendix with potentially different outcomes depending on pathogenesis. Although not proven, obstruction of the appendiceal lumen is believed to be an important step in the development of appendicitis— at least in some cases. Here, obstruction leads to bacterial overgrowth and luminal distension, with an increase in intraluminal pressure that can inhibit the flow of lymph and blood. Then, vascular thrombosis and ischemic necrosis with perforation of the distal appendix may occur. For this reason, perforation that occurs near the base of the appendix should raise concerns about another disease process. Most patients who will perforate do so before they are evaluated by surgeons. Appendiceal fecaliths (or appendicoliths) are found in ~50% of patients with gangrenous appendicitis who perforate but are rarely identified in those who have simpler disease. This suggests that the underlying pathophysiologic processes are different. Uncomplicated appendicitis (e.g., without gangrenous necrosis, appendicoliths, perfo ration, or tumors) does not always progress to perforation. It appears that at least some cases of simple acute appendicitis may temporarily resolve or be managed with antibiotic therapy, although at

least onethird will require subsequent appendectomy. Nevertheless, appen dicitis does not invariably progress to perforation, and the use of nonoperative therapies to treat uncomplicated appendicitis continues to be studied intensively. These findings highlight the importance of clinical decision-making and risk assessment when deciding and discussing treatment options with patients who presumably have simple disease, for example, decid ing who is an appropriate candidate for nonoperative management and who is not without bias. The latter is especially pertinent given the difficulty in assessing which patients might progress to perforation and which will not. When perforation occurs, the resultant leak may be contained by the omentum or other surrounding tissues to form an abscess. Free

TABLE 342-1 Some Conditions That Mimic Appendicitis Crohn’s disease Cholecystitis or other gallbladder disease COVID-19 infection occasionally co-incident Diverticulitis Ectopic pregnancy Endometriosis Gastroenteritis or colitis Gastric or duodenal ulceration Hepatitis Kidney disease, including nephrolithiasis Liver abscess Meckel’s diverticulitis Mittelschmerz Mesenteric adenitis Omental torsion Pancreatitis Lower lobe pneumonia Pelvic inflammatory disease Ruptured ovarian cyst or other cystic disease of the ovaries Small-bowel obstruction Urinary tract infection perforation normally causes severe peritonitis. These patients may also develop infective suppurative thrombosis of the portal vein and its tributaries along with intrahepatic abscesses. The prognosis of the very unfortunate patients who develop this rare but dreaded complication is very poor. ■ ■CLINICAL MANIFESTATIONS Improved diagnosis, supportive care, and surgical interventions are likely responsible for the remarkable decrease in the risk of mortal ity from simple appendicitis to currently <1%. Nevertheless, it is still important to identify patients who might have appendicitis as early as possible. Patients who have persistent symptoms that have not improved over 48 h may be more likely to perforate or develop other complications. Appendicitis should be included in the differential diagnosis of abdominal pain for every patient in any age group unless it is certain that the organ has been previously removed (Table 342-1). The appendix’s anatomic location, which varies, may directly influ ence how the patient presents. Where the appendix can be “found” ranges from local differences in how the appendiceal body and tip lie relative to its attachment to the cecum (Figs. 342-1 and 342-2), to where the appendix is actually situated in the peritoneal cavity—for example, from its typical location in the right lower quadrant, to the pelvis, right flank, right upper quadrant (as may be observed during pregnancy), or even the left side of the abdomen for patients with mal rotation or who have severely redundant colons. Because the differential diagnosis of appendicitis is so extensive, deciding if a patient has appendicitis can be difficult (Table 342-2). Many patients may not present with the classically described history or physical findings, and some may not have any abdominal discomfort early in the disease process. Soliciting an appropriate history requires detecting and evaluating symptoms that might suggest alternative diagnoses. 0.5% 64% 1% 32% 2% FIGURE 342-1 Regional anatomic variations of the appendix.

FIGURE 342-2 Locations of the appendix and cecum. What is the classic history? Nonspecific complaints occur first. Patients may notice changes in bowel habits or malaise and vague, perhaps intermittent, crampy abdominal pain in the epigastric or peri umbilical region. The pain subsequently migrates to the right lower quadrant over 12–24 h, where it is sharper and can be definitively local ized as transmural inflammation when the appendix irritates the pari etal peritoneum. Parietal peritoneal irritation may be associated with local muscle rigidity and stiffness. Patients with appendicitis will most often observe that their nausea, if present, followed the

development of abdominal pain, which can help distinguish them from patients with gastroenteritis, for example, in whom nausea occurs first. Emesis, if present, also occurs after the onset of pain and is typically mild and scant. Thus, timing of the onset of symptoms and the characteristics of the patient’s pain and any associated findings must be rigorously assessed. Anorexia is so common that the diagnosis of appendicitis should be questioned in its absence. Arriving at the correct diagnosis is even more challenging when the appendix is not located in the right lower quadrant, in women of childbearing age, and in the very young or elderly. Because the differ ential diagnosis of appendicitis is so broad, often the key question to answer expeditiously is whether the patient has appendicitis or some other condition that requires immediate operative intervention. A major concern is that the likelihood of a delay in diagnosis is greater TABLE 342-2 Relative Frequency of Common Presenting Symptoms SYMPTOMS FREQUENCY Abdominal pain

> 95% Anorexia 70% Constipation 4–16% Diarrhea 4–16% Fever 10–20% Migration of pain to right lower quadrant 50–60% Nausea 65% Vomiting 50–75%

TABLE 342-3 Relative Frequency of Some Presenting Signs SIGNS FREQUENCY Abdominal tenderness

> 95% Right lower quadrant tenderness 90% Rebound tenderness 30–70% Rectal tenderness 30–40% Cervical motion tenderness 30% Rigidity ~10% Psoas sign 3–5% Obturator sign 5–10% Rovsing’s sign 5% Palpable mass <5% if the appendix is unusually positioned. All patients should undergo a rectal examination. An inflamed appendix located behind the cecum or below the pelvic brim may prompt very little tenderness of the ante rior abdominal wall. Patients with pelvic appendicitis are more likely to present with dysuria, urinary frequency, diarrhea, or tenesmus. They may only experience pain in the suprapubic region on palpation or on rectal or pelvic examination. A pelvic examination in women is mandatory to rule out conditions affecting urogynecologic organs that can cause abdominal pain and mimic appendicitis such as pelvic inflammatory disease, ectopic pregnancy, and ovarian torsion. None of the currently available decision tools yet appear to be able to circumvent or obviate the need for expert clinical opinion. The relative frequencies of some presenting signs are displayed in Table 342-3. CHAPTER 342 Patients with simple appendicitis normally only appear mildly ill with a pulse and temperature that are usually only slightly above nor mal. The provider should be concerned about other disease processes beside appendicitis or the presence of complications such as perfora tion, phlegmon, or abscess formation if the temperature is >38.3°C (~101°F) and if there are rigors. Acute Appendicitis and Peritonitis Patients with appendicitis will be found to lie quite still to avoid peritoneal irritation caused by movement, and some will report dis comfort caused by a bumpy car ride on the way to the hospital or clinic, coughing, sneezing, or other actions that replicate a Valsalva maneuver. The

> entire abdomen should be examined systematically starting in an area where the patient does not report discomfort if possible. Clas sically, maximal tenderness is identified where the appendix is most often located—in the right lower quadrant at or near McBurney's point, which is approximately one-third of the way along a line originating at the anterior iliac spine and running to the umbilicus. Gentle pressure in the left lower quadrant may elicit pain in the right lower quadrant if the appendix is located there. This is Rovsing's sign (Table 342-4). Evidence of parietal peritoneal irritation is often best elicited by gentle abdominal percussion, jiggling the patient's gurney or bed, or mildly bumping the feet. Atypical presentation and pain patterns are common, especially in the very old or the very young. Diagnosing appendicitis in children can be especially challenging because they tend to respond so dramatically to stimulation and obtaining an accurate history may be difficult. In addition, it is important to remember that the smaller omentum found in children may be less likely to wall off an appendiceal perforation. Observing the child in a quiet surrounding may be helpful. TABLE 342-4 Classic Signs of Appendicitis in Patients with Abdominal Pain MANEUVER FINDINGS Rovsing's sign Palpating in the left lower quadrant causes pain in the right lower quadrant Obturator sign Internal rotation of the hip causes pain, suggesting the possibility of an inflamed appendix located in the pelvis Iliopsoas sign Extending the right hip causes pain along posterolateral back and hip, suggesting retrocecal appendicitis

Signs and symptoms of appendicitis can be subtle in the elderly who may not react as vigorously to appendicitis as younger people. Pain, if noticed, may be minimal and have originated in the right lower quad rant or, otherwise, where the appendix is located. It may never have been noticed to be intermittent, or there may only be significant dis comfort with deep palpation. Nausea, anorexia, and emesis may be the predominant complaints. The rare patient may even present with signs and symptoms of distal bowel obstruction secondary to appendiceal inflammation and phlegmon or abscess formation.

■ ■LABORATORY TESTING Laboratory testing does not identify patients with appendicitis. The white blood cell count is only mildly to moderately elevated in ~70% of patients with simple appendicitis (with a leukocytosis of 10,000– 18,000 cells/μL). A "left shift" toward immature polymorphonuclear leukocytes is present in >95% of cases. A sickle cell preparation may be prudent to obtain in those of African, Spanish, Mediterranean, or Indian ancestry. Serum amylase and lipase levels should be measured. Urinalysis is indicated to help exclude genitourinary conditions that may mimic acute appendicitis, but a few red or white blood cells may be present as a nonspecific finding. An inflamed appendix that abuts the ureter or bladder may cause sterile pyuria or hematuria. Every woman of childbearing age should have a pregnancy test. Cervical cul tures are indicated if pelvic inflammatory disease is suspected. Anemia and guaiac-positive stools should raise concern about the presence of other diseases or complications such as cancer. ■ ■IMAGING Plain films of the abdomen are rarely helpful and so are not routinely obtained unless the clinician is worried about other conditions such as intestinal obstruction, perforated viscus, or ureterolithiasis. Less than 5% of patients will present with an opaque fecalith in the right lower

quadrant. The presence of a fecalith is not diagnostic of appendicitis, although its presence in an appropriate location where the patient com plains of pain is suggestive and is associated with a greater likelihood of complications. PART 10 Disorders of the Gastrointestinal System The effectiveness of ultrasonography as a tool to diagnosis appen dicitis is highly operator dependent. Even in very skilled hands, the appendix may not be visualized. Its overall sensitivity is ~0.86, with a specificity of 0.81. Ultrasonography, especially intravaginal techniques, appears to be most useful for identifying pelvic pathology in women. Ultrasonographic findings suggesting the presence of appendicitis include wall thickening, an increased appendiceal diameter, and the presence of free fluid. Current practice in some institutions is to first perform ultrasonography and progress to other imaging studies only if the findings are equivocal or complications are suspected. The sensitivity and specificity of computed tomography (CT) are at least 0.94 and 0.95, respectively. Thus, CT imaging, given its high negative predictive value, especially with the safe use of oral and intra venous contrast, may be helpful if the diagnosis is in doubt, although studies performed early in the course of disease may not have any typi cal radiographic findings. Overall, in patients in whom the diagnosis is uncertain, delaying operation at the time of presentation to obtain CT does not appear to increase the risk of perforation. CT scanning is a superior method for assessing the severity of acute appendicitis in the absence of peritoneal findings indicative of perforation, abscess, or suspicion of an associated malignancy. Suggestive findings on CT examination include dilatation >6 mm with wall thickening, a lumen that does not fill with enteric contrast, and fatty tissue stranding or air surrounding the appendix, which sug gests inflammation (Figs. 342-3 and 342-4). The presence of luminal air or contrast is not consistent with a diagnosis of appendicitis. Fur thermore, nonvisualization of the appendix is a nonspecific finding that should not be used to rule out the presence of appendiceal or periappendiceal inflammation. ■ ■SPECIAL PATIENT POPULATIONS Appendicitis is the most common extrauterine general surgical emer gency observed during pregnancy. Early symptoms of appendicitis such as nausea and anorexia may be overlooked. Diagnosing appendicitis

FIGURE 342-3 Computed tomography with oral and intravenous contrast of acute appendicitis. There is thickening of the wall of the appendix and periappendiceal stranding (arrow). in pregnant patients may be especially difficult because as the uterus enlarges the appendix may be pushed higher along the right flank even to the right upper quadrant or because the gravid uterus may obscure typi cal physical findings. Ultrasonography may facilitate early diagnosis. A high index of suspicion is required because of the effects of unrecognized and untreated appendicitis on the fetus. For example, the fetal mortality rate is four times greater (from 5 to 20%) in patients with perforation. Immunocompromised patients may present with only mild tender ness and may have many other disease processes in their differential diagnosis, including atypical infections from mycobacteria, Cytomega lovirus, or other fungi. Enterocolitis is a concern and may be present in patients who present with abdominal pain, fever, and neutropenia due to chemotherapy. CT imaging may be very helpful, although it is important not to be overly cautious and delay operative intervention for those patients who are believed to have appendicitis. TREATMENT Acute Appendicitis In the absence of contraindications, most patients who have strongly suggestive medical histories and physical examinations FIGURE 342-4 Appendiceal fecalith (arrow).

with supportive laboratory findings are candidates for appendec tomy. Certainly, in some instances, imaging studies are not manda tory but are often obtained before surgical consultation is requested. Imaging and close observation are appropriate in patients whose evaluations are

suggestive but not convincing. Of course, CT may accurately indicate the other intraabdomi nal processes that warrant intervention. Whenever the diagnosis is uncertain, it is prudent to observe the patient and repeat the abdominal examination over 6–8 h. Any evidence of progression is an indication for operation. Narcotics can be given to patients with severe discomfort after an initial, thorough examination. All patients should be fully prepared for surgery and have any fluid and electrolyte abnormalities corrected. Either laparoscopic or open appendectomy is a satisfactory choice for patients with uncomplicated appendicitis, although most procedures are now performed in a minimally invasive fashion to the patient's benefit in terms of recovery time and fewer overall potential complications. Endoscopic treatment for patients with uncomplicated appendicitis is being evaluated for efficacy. Management of those who present with a mass representing a phlegmon or abscess can be more difficult. Such patients are most commonly treated with broad-spectrum antibiotics, percutaneous drainage especially if an abscess is noted >3 cm in diameter, paren teral fluids, and bowel rest. If they appear to respond to conserva tive management, the appendix can then be more safely removed 6–12 weeks later when inflammation has diminished. A laparoscopic approach may also be useful when the exact diagnosis is uncertain. A laparoscopic approach may also facilitate exposure in those who are very obese. Absent complications, most patients can be discharged within 24–40 h of operation. The most common postoperative complications are fever and leukocytosis. Continuation of these findings beyond 5 days should raise concern for the presence of an intraabdominal abscess. The mortality rate for uncomplicated, nonperforated appendicitis is 0.1–0.5%, which approximates the overall risk of general anesthesia. The mortal ity rate for perforated appendicitis or other complicated disease is much higher, ranging from 3% overall to as high as 15% in the elderly. ACUTE PERITONITIS Acute peritonitis, or inflammation of the visceral and parietal perito neum, is most often but not always infectious in origin, resulting from perforation of a hollow viscus. This is called secondary peritonitis, as opposed to primary or spontaneous peritonitis, when a specific intraab dominal source cannot be identified. In either instance, the inflamma tion can be localized or diffuse. ■ ■ETIOLOGY Infective organisms may contaminate the peritoneal cavity after spillage from a hollow viscus, because of a penetrating wound of the abdominal wall, or because of the introduction of a foreign object like a peritoneal dialysis catheter or port that becomes infected. Secondary peritonitis most commonly results from perforation of the appendix, colonic diverticula, or the stomach and duodenum. It may also occur as a complication of bowel infarction or incarceration, cancer, inflamma tory bowel disease, and intestinal obstruction or volvulus. Conditions that may cause secondary bacterial peritonitis and their mechanisms are listed in Table 342-5. Over 90% of the cases of primary or sponta neous bacterial peritonitis occur in patients with ascites or hypopro teinemia (<1 g/L). Aseptic peritonitis is most commonly caused by the abnormal presence of physiologic fluids such as gastric juice, bile, pancreatic enzymes, blood, or urine. It can also be caused by the effects of nor mally sterile foreign bodies such as surgical sponges or instruments. More rarely, it occurs as a complication of systemic diseases such as lupus erythematosus, porphyria, and familial Mediterranean fever. The chemical irritation caused by stomach acid and activated pancreatic enzymes is extreme, and secondary bacterial infection may occur.

TABLE 342-5 Conditions Leading to Secondary Bacterial Peritonitis Bowel perforation Appendicitis Anastomotic leakage Adhesion Diverticulitis Iatrogenic (including endoscopic Perforation or leakage of other organs Biliary leakage (e.g., after liver biopsy) Cholecystitis Intraperitoneal bleeding Pancreatitis Salpingitis Urinary bladder Loss of peritoneal integrity Intraperitoneal chemotherapy Iatrogenic (e.g., postoperative perforation) Ingested foreign body Inflammation Intussusception

Neoplasms Obstruction Peptic ulcer disease Strangulated hernia Vascular (including ischemia or foreign body) Perinephric abscess Peritoneal dialysis or other indwelling devices Trauma embolus) Trauma (blunt or penetrating) ■ ■CLINICAL FEATURES The cardinal signs and symptoms of peritonitis are acute, typically severe, abdominal pain with tenderness and fever. How patients' com plaints of pain are manifested depends on their overall physical health and whether the inflammation is diffuse or localized. Elderly and immunosuppressed patients may not respond as aggressively to the irritation. Diffuse, generalized peritonitis is most often recognized as diffuse abdominal tenderness with guarding, rigidity, and other evidence of parietal peritoneal irritation. Physical findings may only be identified in a specific region of the abdomen if the intraperitoneal inflammatory process is limited or otherwise contained as may occur in patients with uncomplicated appendicitis or diverticulitis. Bowel sounds are usually absent to hypoactive but are not reliable as a physical finding. CHAPTER 342 Acute Appendicitis and Peritonitis Most patients present with tachycardia and signs of volume deple tion with hypotension. Laboratory testing typically reveals a significant leukocytosis, and patients may be severely acidotic. Radiographic stud ies may show dilatation of the bowel and associated bowel wall edema. Free air or other evidence of leakage requires attention and could represent a surgical emergency. In stable patients in whom ascites is present, diagnostic paracentesis is indicated, where the fluid is tested for protein and lactate dehydrogenase and the cell count is measured. ■ ■THERAPY AND PROGNOSIS Whereas mortality rates can be <10% for reasonably healthy patients with relatively uncomplicated, localized peritonitis, mortality rates

> 40% have been reported for the elderly or immunocompromised. Successful treatment depends on correcting any electrolyte abnormali ties, restoration of fluid volume and stabilization of the cardiovascular system, appropriate antibiotic therapy, and surgical correction of any underlying abnormalities. Acknowledgment The wisdom and expertise of Dr. William Silen are gratefully acknowl edged in this updated chapter on acute appendicitis and peritonitis. ■ ■FURTHER READING Andersson RE: Short-term complications and long-term morbidity of laparoscopic and open appendicectomy in a national cohort. Br J Surg 101:1135, 2014. Buckius MT et al: Changing epidemiology of acute appendicitis in the United States: Study period 1993–2008. J Surg Res 175:185, 2012. CODA Collaborative: A randomized trial comparing antibiotics with appendectomy for appendicitis. N Engl J Med 383:1907, 2020. Di Saverio S et al: Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. World J Emerg Surg 15:27, 2020. Drake FT et al: Time to appendectomy and risk of perforation in acute appendicitis. JAMA Surg 149:837, 2014.

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